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USRL Quarterly Report of

RESEARCH, DEVELOPMENT, and CALIBRATION ACTIVITIES

for the Quarter Ending 30 September 1962

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USRL Quarterly Report of

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RESEARCH, DEVELOPMENT, and CALIBRATION ACTIVITIES.

for the Quarter Ending 30 September 1962

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Compiled and Edited by E. A./Barnes

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RESEARCH AND DEVELOPMENT PROJECTS

Research and Development Projects in which definite progress occurred during the reporting period are listed below in numerical order under the following separate categories: "Methods of Measurement and Data Processing," "Transducers and Acoustic Materials," and "Measuring Systems and Instrumentation."

METHODS OF MEASUREMENT AND DATA PROCESSING

Project No. AR-056

NEAR-FIELD STUDY

13-608-1515

Project Scientist: W. J. Trott

Purpose: To study acoustic wave propagation in both the near and far fields of a radiator to ascertain whether the far-field characteristics of a transducer can be determined from near-field measurements, and to analyze practical methods for using near-field measurements to evaluate far-field performance of transducers.

References:

- (a) W. J. Trott, "Near-Field Study," USRL Quarterly Report No. 2-62, Project No. AR-056, page 1.
- (b) Heinrich Stenzel, Leitfaden zur Berechnung von Schallvorgängen [Handbook for the Calculation of Sound Propagation Phenomena] (Julius Springer, Berlin, 1939). NRL Translation No. 130, page 70.

Progress: The array H33 No. 4, described in reference (a), and consisting of seven vertical lines based on binomial coefficients for a power of 7, was used to calibrate in the near sound field a 4 x 5-element array of F31 elements and a DT33A transducer in the frequency range 11 to 16 kc. Transmitting current response, receiving voltage sensitivity, and directivity of both the array and the DT33A circular piston were measured by near-field and far-field methods. Comparison of the results is shown in Figs. 1 through 4.

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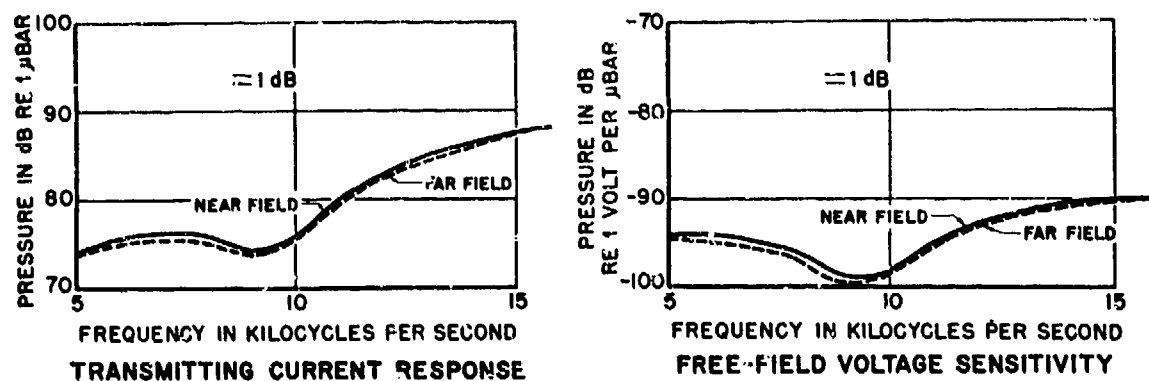


Fig. 1. Characteristics of a 4 x 5-element array (22 x 28 cm) of F31 elements as determined from near- and far-field measurements.

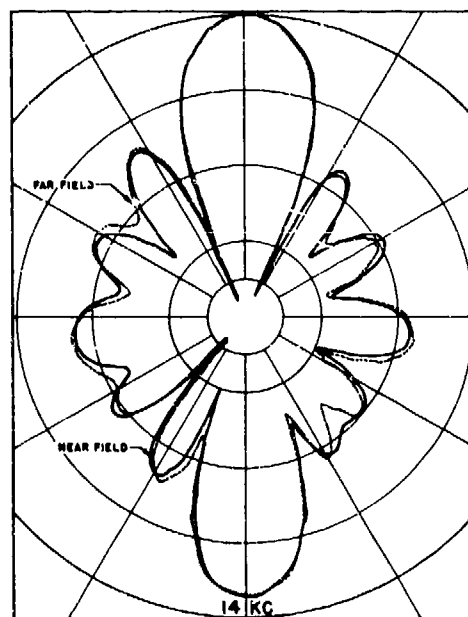


Fig. 2. Directivity of 4 x 5-element array of F31 elements, from near- and far-field measurements. Scale: center to top of grid equals 40 dB.

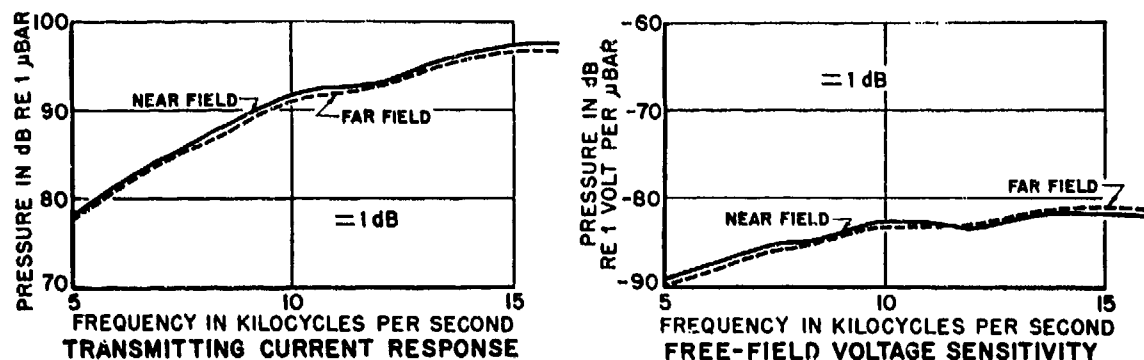


Fig. 3. Characteristics of 23-cm-diameter circular piston DT33A transducer as determined from near- and far-field measurements.

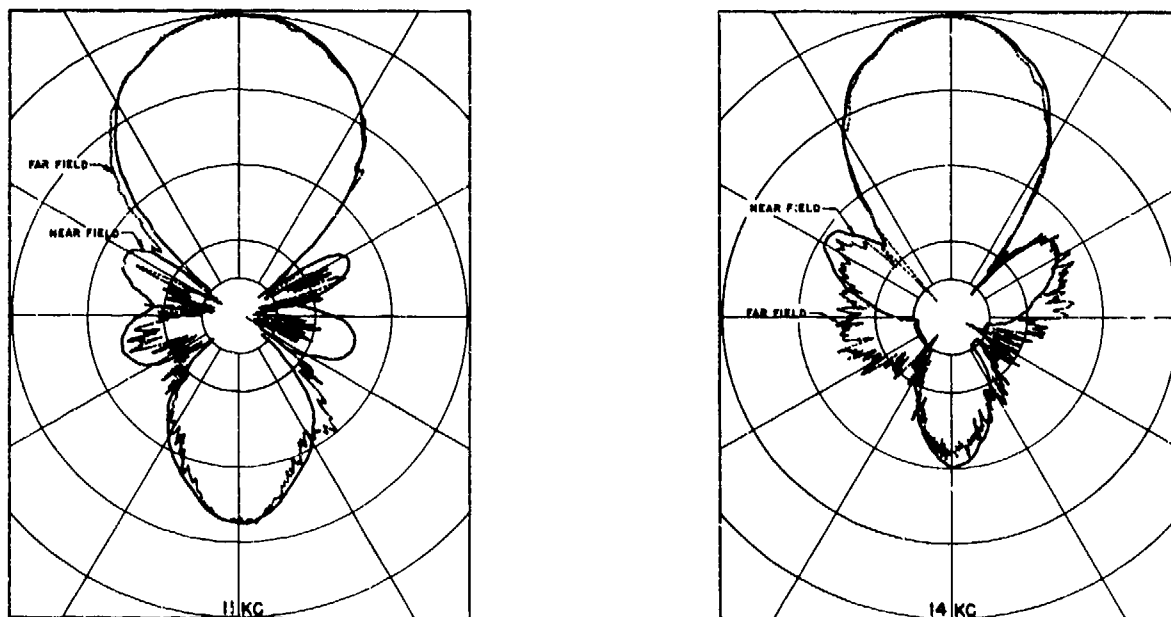


Fig. 4. Directivity of 23-cm-diameter circular piston DT33A transducer from near- and far-field measurements. Scale: center to top of grid, both patterns, equals 40 dB.

The need for a special near-field measuring transducer was proved by using a 44-cm-diameter circular piston, the F22 transducer, and pulsed sound to make near-field measurements on the F31 array. The far-field measured response and the near-field data showed a spread of as much as 6 dB in the range 10 to 30 kc. By computation of the sound pressure on the beam axis, based on Eq. 111a, reference (b), the near-field data were corrected to within 2 dB of the far-field measured sensitivity. Figure 5

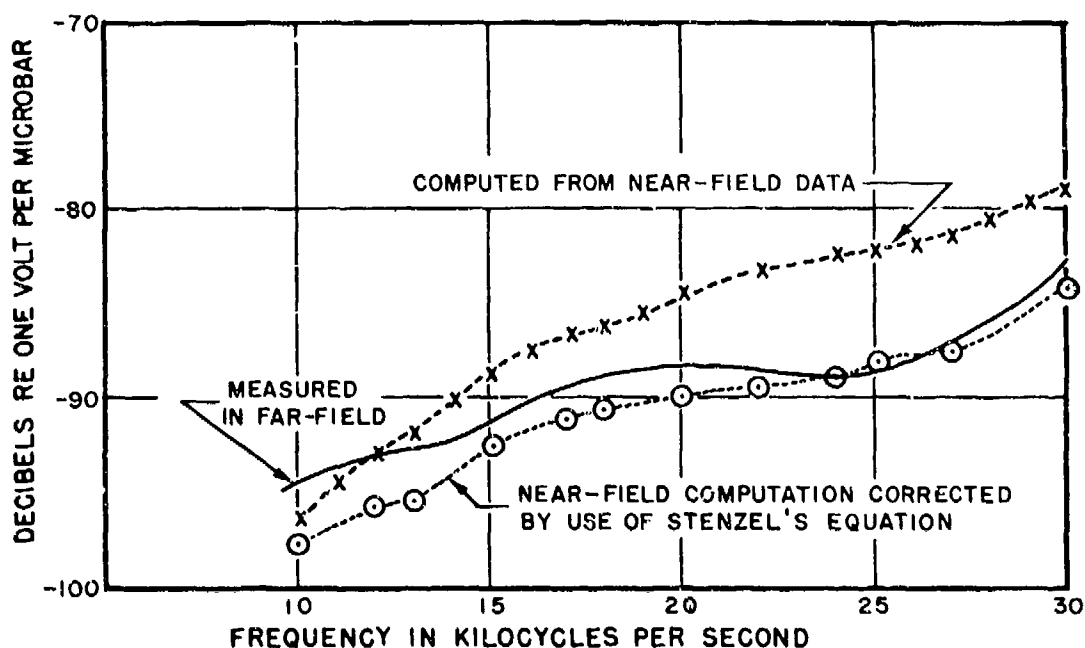


Fig. 5. Voltage sensitivity of 4 x 5-element array (22 x 28 cm) of F31 elements.

shows the measured far-field and near-field response and also the values computed by the use of Eq. 111a.

The University of Florida, Computing Center, was asked to compute the directivity (the sum of zero-order Bessel functions) of four concentric rings, adjusting the source level and the radii to suppress minor lobes. The best result for four rings is

$$p(\theta) = 20J_0(u) + 24J_0(0.695u) + 21J_0(0.400u) + 7J_0(0.127u)$$

where $u = \pi(d_1/\lambda) \sin \theta$, and d_1 is the diameter of the outer ring, consisting of 20 equal point sources. This equation was first developed by selecting source strengths for which the radial density was proportional to the Gaussian curve. A slight improvement was found by using the computer. The results showed the first minor lobe 32 dB down and the second minor lobe 28 dB down. The Computing Center was also given an expression for the summation of zero-order Bessel functions for eight concentric rings, but for this condition the original equation was not improved upon. This equation is

$$p(\theta) = 20J_0(u) + 24J_0(0.867u) + 28J_0(0.734u) + 30J_0(0.600u) \\ + 29J_0(0.467u) + 23J_0(0.330u) + 15J_0(0.200u) + 5J_0(0.067u).$$

For this configuration the minor lobes are -27 and -33½ dB. The beam width between nulls is 35° for five wavelengths across the array. The directivity of an unshaded piston of diameter equal to five wavelengths would have 28½° between the nulls.

An unshaded piston represented by an equivalent shaded line agrees with the Gaussian curve $\exp(-x^2)$ for small values of x if the piston radius $a = 0.5$. From the first two terms in the series expansion of the exponential curve and the equivalent line shading, the piston has a radius $a = 0.707$ for agreement. A piston as an equivalent shaded line, plus three concentric rings, was used as a basis for making up a transducer array for which the source strength as a shaded line equivalent matched the distribution of the Gaussian curve. Nine examples with various selections of radii for piston and rings were submitted to Martin-Marietta Company, Computing Center, Orlando, to obtain the best configuration to minimize minor lobes out to a value of $u = 16$, where $u = \pi(d/\lambda) \sin \theta$, d = piston diameter, and θ = angle from the beam axis. A Pace 231R analog computer was used. One of the nine examples was set up, and the magnitude of the area under the curve beyond the first axis crossing point was summed. The source strength and the radii of the three concentric rings with respect to the center piston array were then adjusted until the area curve was a minimum up to $u = 16$. Five equations similar in the distribution of source strength and radii resulted. An example is given by the equation

$$p(\theta) = 2(64)[J_1(u)]/u + 23J_0(1.226u) + 23J_0(1.518u) + 16J_0(1.845u).$$

This configuration gave 35° between nulls for five wavelengths across the array, compared with 28½° for the same number of wavelengths across the piston. However, at the 6-dB-down points, this array has a beam width of 17° compared with 16½° for a piston. This array is being constructed. The center piston will have 64 elements and a diameter of 32½ inches. The outer ring will have a diameter of 60 inches.

TRANSDUCERS AND ACOUSTIC MATERIALS

Project No. AR-061

CAVITY-LOADED PISTON ARRAYS

Project Scientists: C. C. Sims and T. A. Henriquez

Purpose: To study the use of tuned cavity-loaded pistons in arrays.

Reference:

- (a) C. C. Sims and T. A. Henriquez, "Cavity-Loaded Piston Arrays," USRL Quarterly Report No. 4-61, Project No. AR-081, page 10.

Progress: The basic design of the cavity-loaded piston transducer described in reference (a) and shown in Fig. 6 has been revised to produce a high-efficiency projector that is unaffected by hydrostatic pressure.

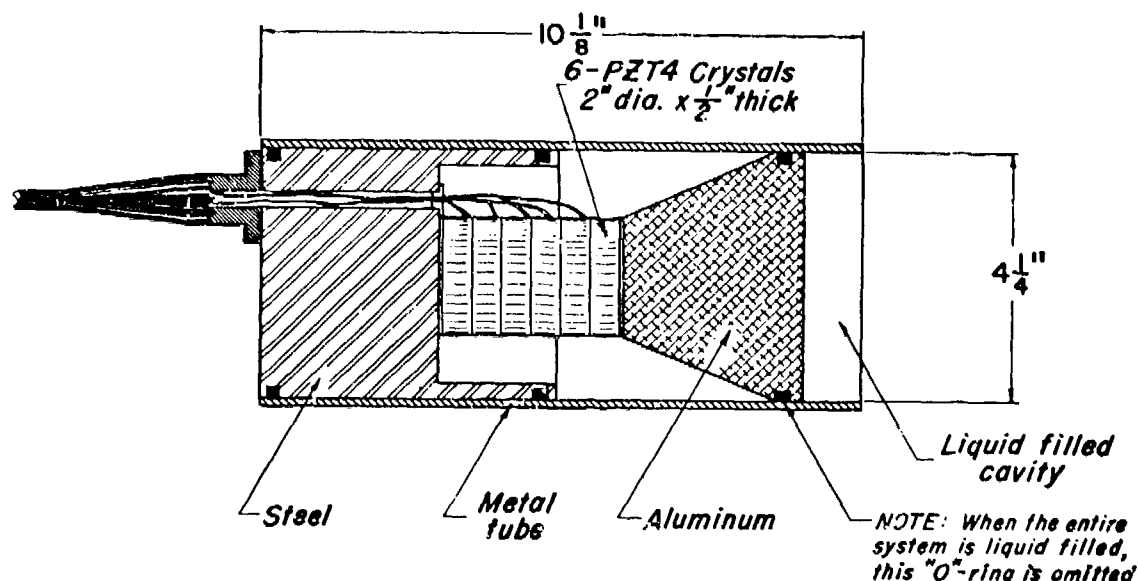


Fig. 6. USRL type G15 cavity piston resonator.

To eliminate the effect of hydrostatic pressure on the transducer, it was necessary to completely fill the transducer with a fluid. The equivalent circuit of the fluid-filled transducer, Fig. 7, differs from the circuit of the unfilled transducer in that it includes a cotangent function Z_B to represent the impedance of the fluid between the piston and the backing mass, and a shunt impedance to represent the fluid in the narrow space between the tube wall and the piston.

The impedance of the fluid in the tube tends to block the motion of the piston at the frequency corresponding to a half wavelength in the fluid between the piston and the back mass. The motion of the fluid between the side of the piston and the wall of the tube produces a loss that is proportional to the viscosity of the fluid. This loss is represented as the series resistance R_d in the equivalent circuit.

Enlarging the clearance between the piston and the wall of the tube would reduce the amount of loss, but would also allow an acoustic "short circuit" between the face and the back of the piston. Judicious juggling of these two parameters is necessary to arrive at the optimum clearance between the piston and the tube wall.

The obvious solution to the problems inherent in the fluid-filled transducer is the use of a fluid with the viscosity and acoustic properties of water, but with very high electrical resistivity. Such an ideal

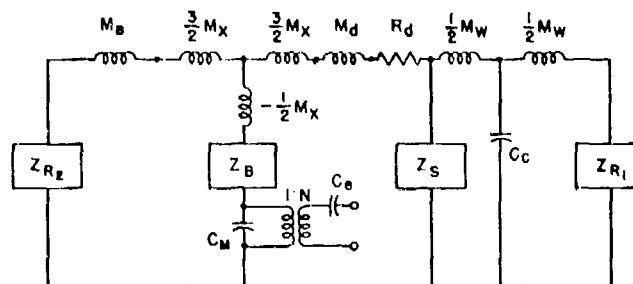


Fig. 7. Equivalent circuit for fluid-filled cavity piston resonator, where C_e = electrical capacitance of free ceramic, C_M = mechanical compliance of open-circuit ceramic, $M_X = 0.4M_T$, M_T = total mass of ceramic stack, M_B = mass of back plate, M_d = mass of aluminum horn, M_W = mass of fluid in cavity, C_C = compliance of fluid in cavity, N = transducer turns ratio, Z_{R1} = radiation load at front of cavity, Z_{R2} = radiation load at back mass, Z_B = impedance of fluid between masses (cotangent function), Z_S = impedance of annular slit, and R_d = viscous loss in annular slit.

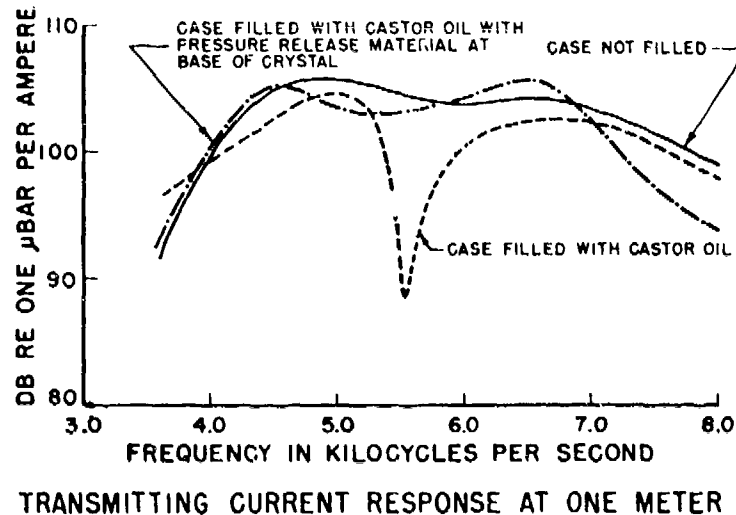


Fig. 8. Transmitting current response at one meter, with various fluids in resonator chamber.

fluid has not yet been found. In the absence of this perfect medium, good results have been obtained with less-than-ideal fluids. Figure 8 shows a comparison of the response of the transducer unfilled, and filled with castor oil. The result of the use of fluid in the tube is clearly seen in the lowered response and the appearance of the sharp hole at the half-wavelength frequency.

The effect of the half-wave condition in the tube was verified by placing pressure-release material at the base of the back mass, thus shifting the phase of the wave reflected by the back mass and eliminating the high impedance of the fluid. This phase shift moves the sharp hole out of the frequency range of interest. The response curves of Fig. 8 are for optimum cavity depth.

Figure 9 shows the result when the cavity is detuned. The cavity resonance shifts away from the mechanical resonance as the depth of the cavity is changed from the optimum value.

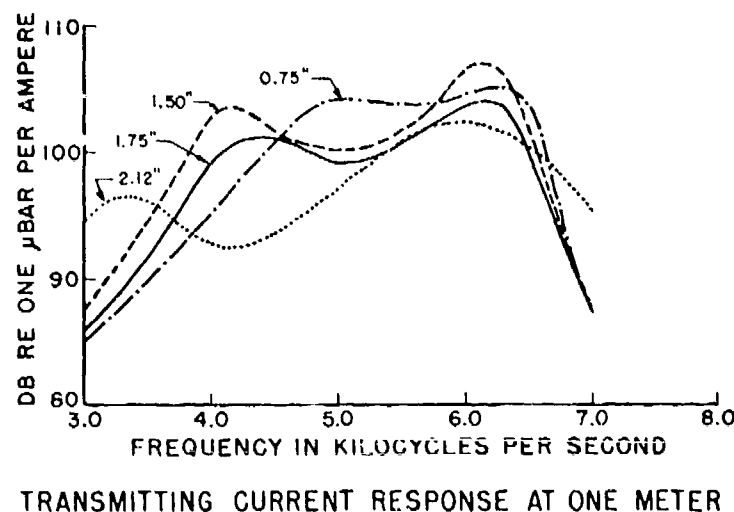


Fig. 9. Effect of cavity depth on transmitting current response.

As an example of the various fluids tested, Fig. 10 shows the characteristics of the transducer when filled with mineral spirits. The advantages of mineral spirits are low viscosity and high resistivity. The disadvantages are low sound speed and the deteriorating action on rubber. Because of the low viscosity of mineral spirits, the efficiency was high (between 80 and 90%). To minimize the effect of the standing wave in the tube, the distance between the back of the piston and the back mass was made smaller. This step raised the frequency for the half-wave condition to a value beyond the range of interest.

In Fig. 11, the directivity of the cavity-loaded transducer is compared with the theoretical directivity of a plane piston in a long tube. As yet there is no theoretical analysis explaining the significant effect of the cavity on the directivity.

There are several possibilities for adding flexibility to this technique. A cavity in the back of the transducer can be used to reduce the back radiation, since certain cavity depths have the effect of reducing the radiation load below that for a plane piston. High-density tungsten

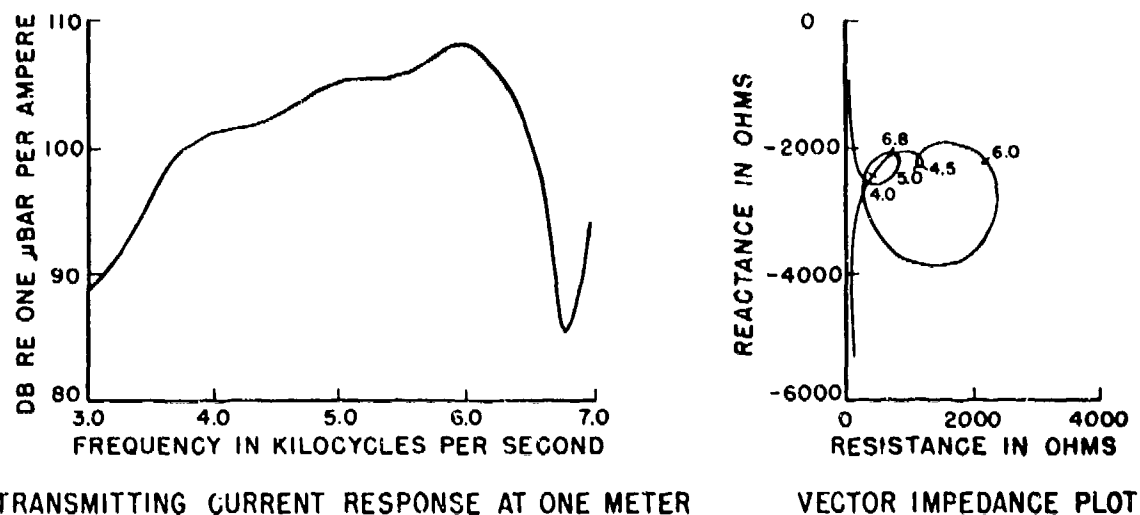


Fig. 10. Characteristics of resonator filled with mineral spirits.

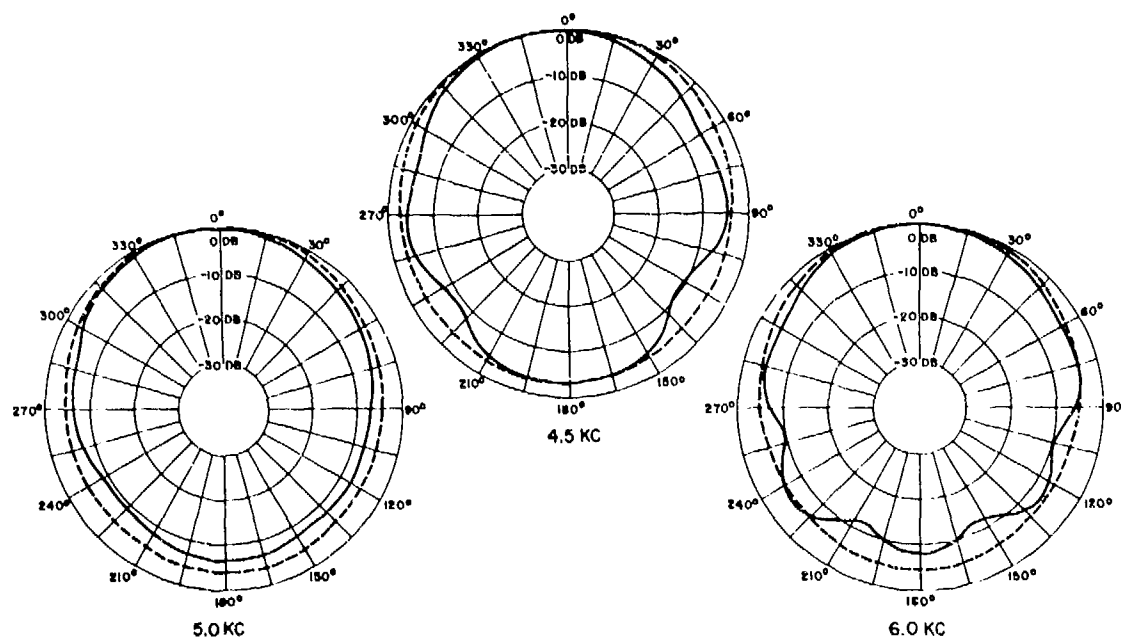


Fig. 11. Comparison of directivity; solid line represents measured directivity of cavity resonator with $\frac{1}{2}$ -inch-deep cavity at end of tube; dashed line represents theoretical directivity of plane piston at end of tube.

used in the back mass would allow a smaller radiating area, while keeping the mass high.

The directivity of a resonator with a back cavity is shown in Fig. 12. The ratio of front cavity depth to back cavity depth is about 1:2. The back radiation in this case is reduced to about 9 dB below that occurring when no back cavity is present.

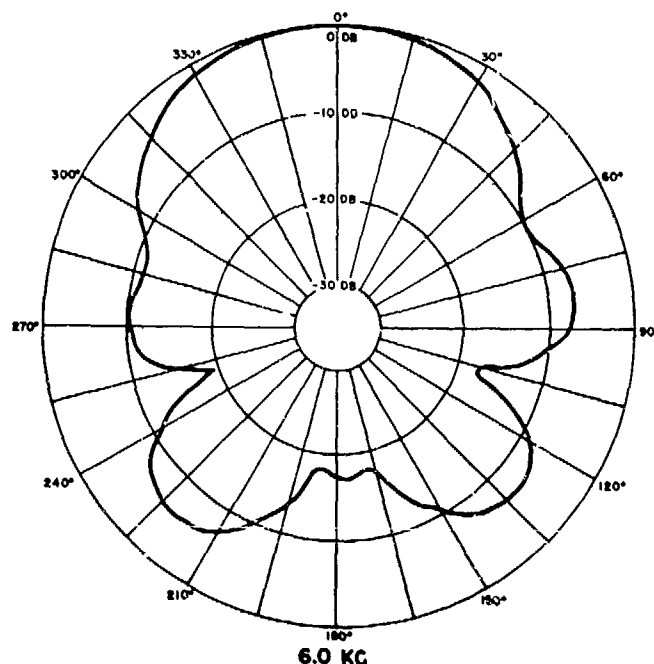


Fig. 12. Directivity with $3/4$ -inch-deep front cavity and $1\frac{1}{2}$ -inch-deep back cavity.

The fluid-filled chamber can also be used to aid in controlling the resonance. A quarter wave in the chamber makes the cotangent function zero. Between a quarter and a half wave, the impedance is a positive reactance that can be used to lower the resonance of the vibrating system.

The work reported here has been largely exploratory. It seems, however, that the method could be valuable in deep-water transducer problems. The possibility of adjusting the radiation load may also be valuable in solving the mutual impedance problem in large arrays.

MEASURING SYSTEMS AND INSTRUMENTATION

Project No. AR-048

CALIBRATION RELIABILITY

Project Scientists: W. L. Paine and H. Dennis

Purpose: To augment existing USRL open-water calibration facilities and provide better free-field measurement conditions for improving calibration accuracy and reliability.

Reference:

- (a) W. J. Trott and R. J. Bobber, "Proposed Deep-Water East Coast Sonar Calibrating Facility," USRL Quarterly Report No. 3-60, Project No. AR-049, page 12.

Background: A proposed east-coast deep-water calibration facility was discussed in reference (a). The cost of the planned facility at Tilly Foster Mine, near Brewster, New York, was considered too large, and the request for implementation of the proposal has been withdrawn. The USRL was requested to select a Florida location that would provide some of the advantages of the Brewster facility with a greater convenience of operation by USRL.

Bugg Spring, a privately owned natural-flowing spring in the vicinity of Leesburg, Florida, was selected as a suitable and practicable location. The spring was first used for acoustic purposes by personnel of David Taylor Model Basin in January 1960 for measurement of the noise produced by buoyant bodies rising vertically through the water after being released from the bottom of the spring. During 1960, the spring was used by USRL to make some acoustic measurements and to check out the equipment used for the evaluation of the Tilly Foster mine. The Bell Telephone Laboratories used the spring in October 1960 for some ambient noise measurements. In April 1961, the USRL obtained a formal permit for exclusive use of the spring, and used it intermittently thereafter for special tasks. In early 1962, funds were obtained for building and instrumenting an interim facility pending approval of funds for a larger installation.

Progress: Until June 1962, measurements at the facility were made from an 8 x 20-foot catamaran raft. In the summer of 1962, a small boat dock was installed, and a 20 x 20-foot barge with a 16 x 16-foot deck house was assembled and moored approximately at the center of the spring. Both the dock and the barge are supported by fiber glass pontoons. The barge was instrumented and placed in operation in August. A photograph of the facility is shown as Fig. 13. Interior views of the mechanical and electronic instrumentation are shown as Figs. 14 and 15.

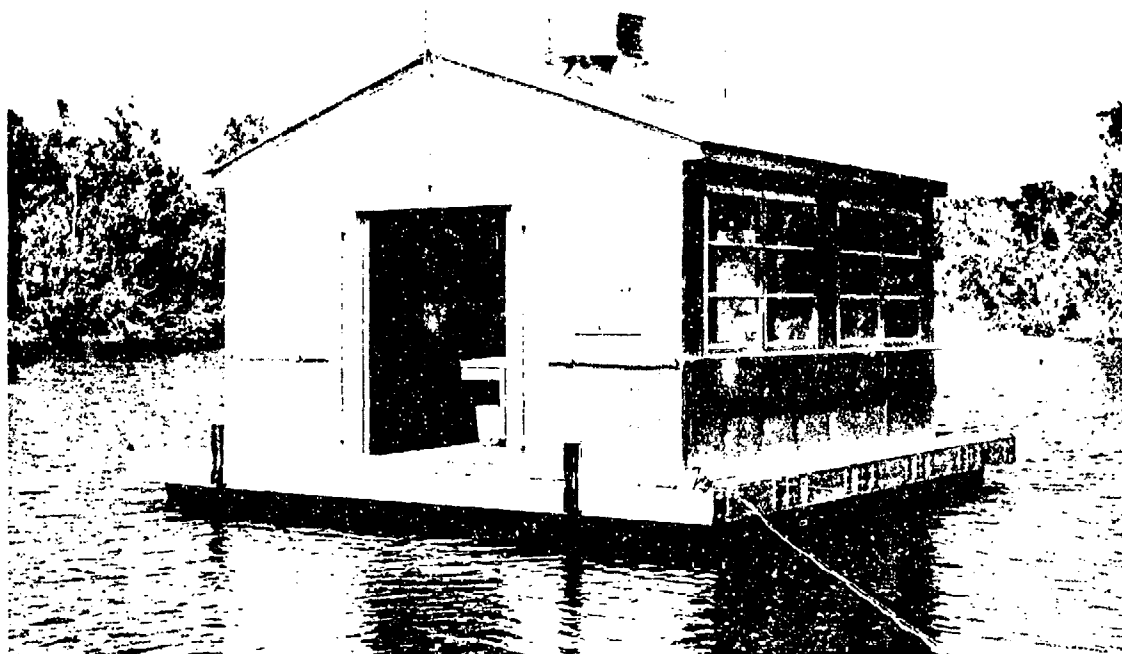


Fig. 13. Floating measurements platform at Leesburg facility.

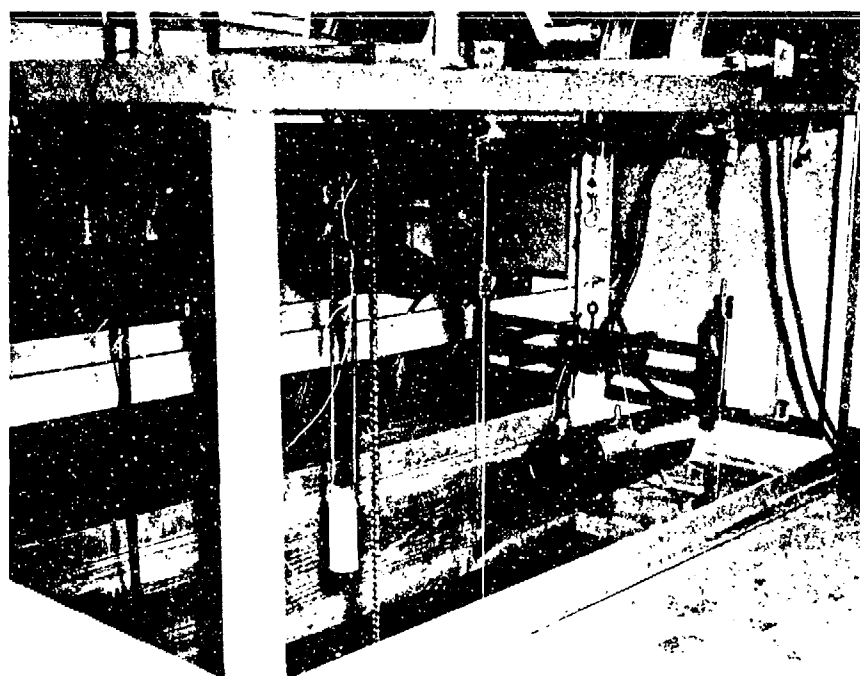


Fig. 14. Test well and transducers.

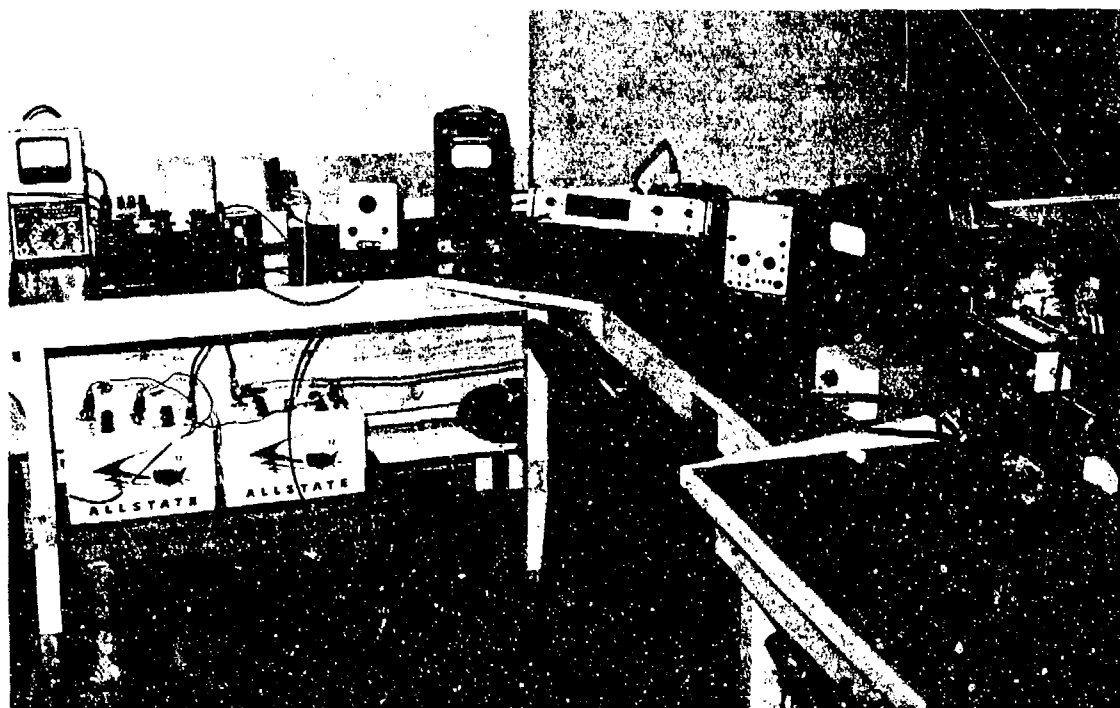


Fig. 15. Electronic instrumentation for Leesburg facility.

The present facility is intended only for the calibration of small, light transducers that require no weight-handling equipment. The electronic equipment is battery-powered to eliminate 60-cps interference when making readings at low frequencies. Measurements are made with continuous-wave signals at discrete frequencies over the range 40 to 20 000 cps.

Sweep-frequency equipment is available but has not been placed in operation. It will be modified for battery operation where necessary, although normal a-c power will be used when possible to minimize battery drain.

Two 2 x 5-foot test wells in the floor of the raft allow test distances up to 10 feet for possible future measurements with pulsed signals. One well is equipped with two transducer supports, each of which is mounted on a pair of small steel guide cables 125 feet long hanging in the well. With a lift cable, reel, and hand crank, a support may be moved vertically along its pair of guide cables. The cables are kept taut and at a set distance between transducer supports by a spacer frame and weights.

Small hydrophones are calibrated at a short test distance to reduce the effect of surface and other reflections that are present in low-frequency c-w measurements. For example, the use of a test distance of 18 inches at a depth of 50 feet reduces the surface-reflected signal level 36 dB below that of the direct signal, resulting in reflection interference of less than ± 0.15 dB.

The dimensions of the spring are tabulated below. At an optimum location it is possible to calibrate at short test distances and depths to 100 feet without any reflecting surface closer than 60 feet.

	Depth (ft)	Length (ft)	Width (ft)
(surface)	0	380	320
	30	300	200
	50	250	175
	100	200	125
	150	175	100
	170	100	60
(bottom)	176	0	0

The water is isothermal; the temperature remains at 22°C throughout the year. Although there is a flow from the spring, there are no noticeable currents. Ambient noise is approximately that of sea state zero, and consists of wave slap and fish sounds. Because of the relatively isolated location of the spring, there are no mechanical noises from highways or trains.

The facility has been used for the calibration of sonobuoy hydrophones at operating depth. Before this time, these hydrophones could not be calibrated over the full operating range at pressure equal to 60-foot depth without using the large anechoic tank. The hydrophones were calibrated in the low-frequency tank over the range 20 to 1000 cps at operating pressure. The Leesburg facility relieves the tank facilities of this work at a considerably reduced cost per hydrophone, and with more complete coverage of frequency.

The true transmitting response of the USRL high-fidelity sound sources types J9 and J11 can now be measured down to their lowest operating frequency. The 30-foot depth of Lake Gem Mary at the Orlando laboratory prevented true measurements at low frequencies because of interference from reflecting surfaces.

The year-around constant temperature and unchanging acoustic conditions make the Leesburg facility nearly ideal for the calibration of standard reference transducers.

The interim facility is not suitable for large and heavy transducers. A larger barge, if authorized, will be planned for measurements on transducers of dimensions to 15 feet and weight to 5 tons, for frequencies as low as 1 kc. Near-field techniques will probably be required.

Conclusion: An interim-type barge at a new deep-water location has augmented the USRL facilities. It provides improved acoustic conditions for special tests that cannot be performed at the Orlando laboratory. An expected dividend is the potential for improving the calibrations of reference hydrophones to an accuracy of better than ± 0.5 dB.

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REQUESTED PROJECTS

The projects in this section of the Report have been selected from projects active at the USRL during the third quarter of 1962. These projects were undertaken in direct or indirect support of the material Bureaus and Offices of the Navy Department, or have otherwise accrued under the mission of the USRL. The projects are listed below in numerical order under the following separate categories: "Shipborne Sonar Equipment," "Airborne Sonar Equipment," "Fixed Sonar Equipment," "Acoustic Torpedo Equipment," "Field and Laboratory Measurement Equipment," "Acoustic Materials," and "Miscellaneous Projects."

SHIPBORNE SONAR EQUIPMENT

Project No. RP-2362 (Confidential)

SANGAMO AN/SQS-23 ARRAY AND ELEMENTS

Calibration measurements were made on Sangamo Electric Company AN/SQS-23 transducer elements in a 3 x 3 array and on elements serials VDS-2 and VDS-3 in connection with Bureau of Ships contract NObsr-87281.

The project consisted of measurement in the open water, in the anechoic tank as a function of hydrostatic pressure at ambient temperature, and remeasurement in the open water.

Measurements on the array and on element serial VDS-2 consisted of transmitting current and voltage response, directivity, equivalent series impedance, and equivalent parallel admittance. Element serial VDS-3 failed during the project.

Transmitting voltage response on the array at 5 kc (the operating frequency) was 75 dB re 1 μ bar at one meter, per volt applied at end of cable. Transmitting voltage response for element serial VDS-2 was 39 dB at 5 kc.

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Measurements were made in the anechoic tank for the hydrostatic pressure range 0 to 500 psig. The response of the array decreased 5 dB upon the application of 500 psig, and the resonance shifted to 5.6 kc. The response of element serial VDS-2 was increased 6 dB by 500 psig, and the resonance shifted to 4.7 kc. After-pressure measurements showed that the responses of the array and the element returned to the original levels. (EMR)

Project No. RP-2429 (Confidential)

TRANSDUCERS FOR PROJECT GLAUCUS

Evaluation measurements were made at the request of the Bureau of Ships on one AT-200(XN-4) transducer of the AN/UQN type that had been modified by the Edo Corporation for use in deep water.

Measurements consisted of transmitting current and voltage response at low and high driving powers, directivity, and impedance in the frequency range 10 to 15 kc at the water temperature 4°C and at hydrostatic pressures to 1000 psig. At the peak frequency, 11.5 kc, the transmitting current response was 110 dB re 1 μ bar/A at 1 m. With 1000 psig pressure the response decreased 9 dB at 10 kc, and increased 1 dB at 15 kc. (PS)

AIRBORNE SONAR EQUIPMENT

Project No. RP-2402 (Confidential)

SONOBUOYS

The noise output caused by the recorder drive motor of each of three sonobuoys built by Sanders Associates, Inc., Nashua, New Hampshire, was measured at the Orlando and the Leesburg facilities of USRL.

Measurements at the Orlando Facility were made using the automatic transmission measuring set with a 14.3-cps filter; those at Leesburg were made with an AN/PQM-1A noise measuring set.

At Leesburg, at the depth of interest, which was 60 feet below the sonobuoy, the noise in the frequency band below 316 cps due to the sonobuoys was no higher than the ambient of 66 to 69 dB re 0.0002 μ bar. In the band 316 to 1000 cps the noise due to sonobuoys was from 4 to 7 dB above the ambient. In the 1000 to 3160 cps band the noise varied from 5 to 10 dB above the ambient. (HD)

Requested Projects

C O N F I D E N T I A L

Project No. RP-2406 (Unclassified)

CHESAPEAKE SONOBUOY HYDROPHONES

Calibration measurements were made at the request of the Chesapeake Instrument Corporation on twelve AN/SSQ-23 sonobuoy hydrophones in connection with Bureau of Naval Weapons contracts NOW 62-0280-f and NOW 62-0282-f.

Measurements consisted of free-field voltage sensitivity in the frequency range 100 cps to 10 kc. The sensitivities were between -88 and -90 dB re 1 V/ μ bar at 1.0 kc.

Low-frequency measurements were made on serials 7 through 12 for the hydrostatic pressure range 0 to 45 psig at the temperatures 5, 21, and 30°C. The sensitivities of the hydrophones were unaffected by hydrostatic pressure, but were 1 to 2 dB higher at 30°C than at 5°C. (EMR)

Project No. RP-2410 (Unclassified)

GULTON SONOBUOY HYDROPHONE

One type AN/SSQ-23 hydrophone was calibrated at the request of the Bureau of Naval Weapons and Gulton Industries.

Free-field voltage sensitivity was measured in the frequency range 100 cps to 10 kc. The sensitivity of this hydrophone was -86 dB re 1 V/ μ bar at 1 kc, and -78 dB at the peak frequency, 4.5 kc. (JLT)

Project No. RP-2416 (Confidential)

CLEVITE SONOBUOY LINE HYDROPHONES

Calibration measurements were made on three Clevite AX439 sonobuoy line hydrophones at the request of the Hazeltine Corporation, in connection with Bureau of Naval Weapons contract NOW 62-0830-c. The hydrophones are for use in the type AN/SSQ-45(XN-1) sonobuoys.

Measurements consisted of free-field voltage sensitivity in the frequency range 100 cps through 10 kc. The arrays were too long to be measured as lines, so all measurements were made with the elements clustered. The sensitivities were between -89 and -91 dB re 1 V/ μ bar over the entire range.

Low-frequency measurements were made in the range 100 to 1000 cps for the hydrostatic pressure range 0 to 800 psig, at ambient temperature. The sensitivities of the hydrophones decreased by 2.5 to 3.0 dB with the application of 800 psig, returning to the original level when the pressure was released. (EMR)

C O N F I D E N T I A L

C O N F I D E N T I A L

Requested Projects

Project No. RP-2425 (Unclassified)

CLEVITE SONOBUOY HYDROPHONES

Calibration measurements were made on six Clevite AN/SSQ-23 type H sonobuoy hydrophones at the request of the Bureau of Naval Weapons and the General Electric Company.

Measurements consisted of free-field voltage sensitivity in the frequency range 100 cps through 10 kc. The sensitivities were between -85 and -86 dB re 1 V/ μ bar at 1 kc.

Measurements at low frequency were made in the range 15 to 1300 cps for hydrostatic pressures from 0 to 27 psig at the temperatures 5, 20, and 30°C. The sensitivities decreased approximately 1 dB when the temperature was decreased from 30 to 5°C. There was no significant change with pressure. (EMR)

Project No. RP-2435 (Unclassified)

GULTON SONOBUOY HYDROPHONES

Calibration measurements were made at the request of the Bureau of Naval Weapons on thirteen type AN/SSQ-28 sonobuoy hydrophones manufactured by Gulton Industries, Inc.

Measurements consisted of free-field voltage sensitivity in the range 100 cps through 10 kc. The sensitivities were between -82 and -85 dB re 1 V/ μ bar at 1 kc. (EMR)

Project No. RP-2436 (Confidential)

GULTON SONOBUOY LINE HYDROPHONES

Calibration measurements were made on two Gulton AN/SSQ-45(XN-1) line hydrophones at the request of the Hazeltine Corporation in connection with Bureau of Naval Weapons contract NOW 62-0830-d.

Measurements consisted of free-field voltage sensitivity in the frequency range 100 cps through 10 kc. The arrays were too long to be measured as lines, so all measurements were made with the elements clustered. The sensitivities were between -88 and -89 dB re 1 V/ μ bar in the range 100 cps to 1.5 kc.

Low-frequency measurements were made in the range 15 to 1300 cps for the hydrostatic pressures 6 and 27 psig at the temperatures 5, 20, and 30°C. The sensitivities increased approximately 1.5 dB when the temperature was increased from 5 to 30°C, but did not change significantly with pressure. (EMR)

C O N F I D E N T I A L

Requested Projects

C O N F I D E N T I A L

Project No. RP-2440 (Unclassified)

CHESAPEAKE SONOBUOY HYDROPHONES

Calibration measurements were made at the request of the Bureau of Naval Weapons on six AN/SSQ-23 hydrophones model SB-154C manufactured by Chesapeake Instrument Corporation.

Measurements consisted of free-field voltage sensitivity in the frequency range 100 cps to 10 kc. The sensitivities of the hydrophones were between -89 and -91 dB re 1 V/ μ bar in the range 100 cps to 1 kc. Resonant peaks 7 dB higher than the level at 1 kc occurred in the region 4 to 5 kc. (DGW)

Project No. RP-2441 (Unclassified)

GULTON SONOBUOY HYDROPHONES

Calibration measurements were made at the request of the Bureau of Naval Weapons on twelve AN/SSQ-23 hydrophones manufactured by Gulton Industries, Inc.

Measurements consisted of free-field voltage sensitivity in the frequency range 100 cps to 10 kc. The sensitivities of the hydrophones ranged from -84 to -88 dB re 1 V/ μ bar in the range 100 cps to 1 kc. (DGW)

Project No. RP-2444 (Confidential)

CLEVITE SONOBUOY LINE HYDROPHONES

Calibration measurements were made on three type AN/SSQ-45(XN-1) sonobuoy line hydrophones at the request of Clevite Ordnance Division, Clevite Corporation in connection with Bureau of Naval Weapons contract NOW 62-0830-c. (See also RP-2416.)

Low-frequency measurements were made in the range 100 cps to 1 kc for the hydrostatic pressures 0, 400, 600, and 800 psig at ambient temperature. The sensitivities at 0 psig were -88 dB re 1 V/ μ bar, but decreased 2 dB with the application of 800 psig.

Open-water measurements were made on serial M103 in the range 100 cps to 10 kc. The sensitivity was -88 dB from 100 cps to 1.5 kc, -89.5 dB at 3 and 4 kc, and -88.5 dB from 6 to 10 kc. All measurements were made with the elements clustered. (EMR)

C O N F I D E N T I A L

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Project No. RP-2450 (Unclassified)

GULTON SONOBUOY HYDROPHONES

Measurements were made on six Gulton AN/SSQ-23 sonobuoy hydrophones submitted by the General Electric Company in connection with Bureau of Naval Weapons contracts NOAs 60-0203-f and NOW 61-0436-f.

The measurements consisted of free-field voltage sensitivity in the frequency range 0.1 to 10 kc. Sensitivities at 1 kc ranged from -83 to -87 dB re 1 V/ μ bar. (RGA)

Project No. RP-2451 (Unclassified)

CLEVITE SONOBUOY HYDROPHONES

Calibration measurements were made at the request of Clevite Ordnance Division, Clevite Corporation, on three AN/SSQ-23 sonobuoy hydrophones in connection with Bureau of Naval Weapons contract NOW-61-0436-f.

Measurements consisted of free-field voltage sensitivity in the frequency range 100 cps through 10 kc. The levels were -85 dB re 1 V/ μ bar at 1 kc. (EMR)

Project No. RP-2460 (Unclassified)

TECHNICAL DYNAMICS SONOBUOY HYDROPHONES

Measurements were made on three type AN/SSQ-23 hydrophones submitted by Technical Dynamics, Inc., in connection with a Bureau of Naval Weapons contract.

The measurements consisted of free-field voltage sensitivity in the frequency range 0.1 to 20 kc. Sensitivities at 1 kc ranged from -76 to -79 dB re 1 V/ μ bar. (RGA)

Project No. RP-2468 (Unclassified)

CLEVITE SONOBUOY HYDROPHONES

Calibration measurements were made on three AN/SSQ-23 sonobuoy hydrophones at the request of Clevite Ordnance Division, Clevite Corporation, in connection with Bureau of Naval Weapons contract NOW 61-0436-f.

Measurements consisted of free-field voltage sensitivity in the frequency range 100 cps through 10 kc. The sensitivities were -87 dB re 1 V/ μ bar at 1 kc. (EMR)

U N C L A S S I F I E D (Reverse side CONFIDENTIAL)

Project No. RP-2473 (Unclassified)

CHESAPEAKE SONOBUOY HYDROPHONES

Calibration measurements were made on ten Chesapeake AN/SSQ-23 sonobuoy hydrophones at the request of the Bureau of Naval Weapons and the General Electric Company.

Measurements consisted of free-field voltage sensitivity in the frequency range 100 cps through 10 kc. The sensitivities of the hydrophones were between -86 and -87 dB re 1 V/ μ bar at 1 kc. (DGW)

FIXED SONAR EQUIPMENT

Project No. 2391 (Unclassified)

HYDRO-TECH HYDROPHONES

Evaluation measurements were made on four Hydro-Tech target-tracking hydrophones at the request of the David Taylor Model Basin in connection with the Lockheed Company contract N600(167)(57545)(X). The hydrophones were produced by the Hydro-Tech Company, and were intended for use in the AUTECH Acoustic Range Project.

Measurements consisted of free-field voltage sensitivity and directivity in the frequency range 15 to 35 kc at hydrostatic pressures to 1000 psig. The free-field voltage sensitivities of the hydrophones ranged between -90 and -95 dB re 1 V/ μ bar. The sensitivities were lowered approximately 10 dB by the application of 1000 psig pressure. (JPS)

Project No. RP-2392 (Confidential)

BENDIX-PACIFIC DX-278 AND DX-279 TRANSDUCERS

Evaluation measurements were made on two DX-278 and two DX-279 transducers designed for use as sonar beacon systems in the AUTECH Acoustic Range. The measurements were requested by the David Taylor Model Basin in connection with the Lockheed Electronics Company contract N600(167)(57545)(X).

Measurements were made under various conditions. Pressure release materials were changed, and transformers within the transducers were tuned to obtain optimum response and impedance. The measurements consisted of directivity, efficiency, sound pressure level, and impedance at the frequencies 2.80, 5.90, 5.95, and 6.00 kc, with hydrostatic pressures of 71 and 643 psig and driving powers of 100 to 115 watts. Results of the measurements were reported in USRL Calibration Report No. 1898. (JPS)

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Project No. RP-2431 (Unclassified)

DTMB FIBER GLASS DOME

Measurements to determine the effect of a streamlined fiber glass housing on the directivity of a small cylindrical transducer were made at the request of the David Taylor Model Basin.

The transducer is normally driven once a second with a 50-kc pulse of 20 milliseconds duration. The housing, or dome, is approximately 8 inches long, $8\frac{1}{2}$ inches deep, and $3\frac{1}{2}$ inches across the beam. The material is $\frac{1}{8}$ -inch thick.

When the transducer was driven in the normal manner, the housing had no adverse effect on the directivity. When a continuous wave was used, the effect was to produce in the directivity pattern variations of $-1\frac{1}{2}$ dB in the forward 180° of the dome, and $-2\frac{1}{2}$ dB in the rear 180° . Transmission loss through the $\frac{1}{8}$ -inch wall was approximately 0.5 dB. (JLT)

Project No. RP-2445 (Confidential)

NMDL MINE HUNTING SONAR SYSTEM

Calibration measurements were made on a mine hunting sonar system and a Nimrod hydrophone at the request of the Navy Mine Defense Laboratory.

The system consisted of a honeycombed fiber glass parabolic reflector 22 inches long, 9 inches high, and 1 inch thick, with a focal length of $14\frac{5}{16}$ inches, a preamplifier, a hydrophone array 8 inches long, 6 inches wide, and 2 inches deep, and a transmitter. The hydrophone contained 28 elements, each with a separate cable. This arrangement permitted measurements to be made on the individual elements.

Measurements on the system in open water consisted of directivity at 100 kc on elements 1 through 3, 5 through 12, and 15. Free-field voltage sensitivity was measured in the high-frequency tank on four elements in the frequency range 100 to 500 kc. The sensitivities of the four elements were -88 dB re 1 V/ μ bar at 100 kc.

The Nimrod hydrophone had a crystal array approximately $7\frac{1}{2}$ inches long and 3 inches high. The free-flooding cover for the array was aluminum with a pc rubber window.

Measurements on this hydrophone in the high-frequency tank consisted of free-field voltage sensitivity and directivity in the XY plane at 200 kc, with and without the cover. The free-field voltage sensitivity at the end of the 191-foot cable was -97 dB re 1 V/ μ bar with the cover, and -95 dB without the cover. (DRH)

C O N F I D E N T I A L

Project No. RP-2447 (Confidential)

NOL EXPERIMENTAL TRANSDUCER ARRAY

Acoustic measurements were made at the request of the U. S. Naval Ordnance Laboratory on an experimental transducer array to determine the effect of hydrostatic pressure on its directivity.

The array consisted of two 32 x 43 x $\frac{1}{2}$ -inch rubber mats bonded to a 1-inch-thick steel plate, with five type BQR-4 line hydrophones mounted vertically 7 inches apart behind the uncoated side of the plate.

Measurements consisted of relative directivity at selected frequencies, water temperatures 3 and 25°C, and hydrostatic pressures to 600 psi. The measurements were made with and without pressure compensation. The measurements showed no change in directivity with changes in temperature or pressure. (JED)

ACOUSTIC TORPEDO EQUIPMENT

Project No. RP-2411 (Confidential)

NOPF MK 44 MOD 0 TRANSDUCERS

Calibration measurements were made on two NOPF Mk 44 Mod 0 transducers at the request of the American Machine and Foundry Company in connection with Bureau of Naval Weapons contract NOW 62-0784.

Measurements consisted of free-field voltage sensitivity, and transmitting current and voltage response in the frequency range 55 to 65 kc, directivity in the XY and XZ planes, and equivalent series impedance. The transmitting current response at 60.5 kc was 108 dB re 1 μ bar/A at 1 yd for serial E1, and 107 dB for serial E2. (EMR)

Project No. RP-2421 (Confidential)

BENDIX-PACIFIC MK 46 TORPEDO TRANSDUCERS

Evaluation measurements were made as requested by the Bureau of Naval Weapons on two Mk 46 Mod 0 torpedo transducers manufactured by Bendix-Pacific Division, Bendix Corporation, under contract NOrd-18326.

Measurements consisted of transmitting current response, sound pressure level, free-field voltage sensitivity, directivity, impedance, and efficiency in the frequency range 20 to 40 kc at the water temperature 25°C and at hydrostatic pressures to 660 psig. Conventional low-power tests

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and tests at high electrical driving power were made. Measurements were made for the several modes of transducer operation and were reported in USRL Calibration Report No. 1903. (JPS)

Project No. RP-2433 (Confidential)

BENDIX-PACIFIC MK 46 TORPEDO TRANSDUCER

Evaluation measurements were made as requested by the Bureau of Naval Weapons on a Mk 46 Mod 0 torpedo transducer manufactured by Bendix-Pacific Division, Bendix Corporation, under contract NOrd-18326. These measurements were a continuation of those reported under Project RP-2421.

Free-field voltage sensitivity, transmitting current response, sound pressure level, directivity, impedance, efficiency, and receive stiffness for the frequency range 20 to 40 kc at the water temperature 20°C and at hydrostatic pressures to 660 psig were measured. Receive stiffness is a measure of the phase difference between the output voltages of two opposite receiving channels as the transducer is rotated horizontally or vertically. Conventional low-power tests and tests at high electrical driving powers were made. The results of the measurements were reported in USRL Calibration Report No. 1926. (JPS)

FIELD AND LABORATORY MEASUREMENT EQUIPMENT

Project No. 2326 (Unclassified)

TR-127/WQM-3 TRANSDUCERS

Measurements were made on five transducers type TR-127/WQM-3 for use with sonar test set AN/WQM-3, at the request of the Bureau of Ships in connection with the POMSEE Program.

Measurements consisted of transmitting voltage response, free-field voltage sensitivity, and directivity in the XY and XZ planes in the frequency range 1 to 50 kc. The free-field voltage sensitivity at 10 kc was -108 dB re 1 V/ μ bar. (DRH)

Project No. RP-2403 (Unclassified)

MASSA TRANSDUCER

Evaluation measurements were made on a TR16S transducer manufactured by Massa Laboratories and considered to be a possible POMSEE replacement. The transducer appears to be satisfactory for such use.

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Measurements consisted of free-field voltage sensitivity, transmitting current and voltage response in the frequency range 1 to 100 kc, and directivity in the XY and XZ planes at frequencies up to 50 kc. The sensitivity was -109 dB re 1 V/ μ bar in the range 5 to 30 kc. The transducer was omnidirectional in the XY plane, and equivalent to a 6-inch line in the XZ plane. (DRH)

Project No. RP-2407 (Unclassified)

ATLANTIC RESEARCH TRANSDUCER

Measurements were made on a type LC10 transducer used by Martin-Marietta Corporation, Orlando, Florida, to monitor the sound pressure in a sonic cleaning tank used in connection with Bureau of Naval Weapons contract NOW 62-0043-1.

Measurements consisted of free-field voltage sensitivity in the frequency range 10 to 100 kc. The sensitivity was -111 to -112 dB re 1 V/ μ bar in the frequency range of interest, 10 to 40 kc. (HD)

Project No. RP-2414 (Unclassified)

TECHNICAL DYNAMICS TRANSDUCER

Type 550355 transducer serial 10001 was calibrated at the request of Technical Dynamics, Inc., to determine its suitability for use as a POMSEE transducer.

Measurements consisted of free-field voltage sensitivity, transmitting current and voltage response, horizontal and vertical directivity, and equivalent series impedance in the frequency range 1 through 50 kc. Response measurements were made at hydrostatic pressures from 0 to 1000 psig at ambient temperature. There was no change in response with pressure, but there was an intermittent loss of signal each time the pressure was reduced from 100 to 0 psig. (JLT)

Project No. RP-2415 (Unclassified)

MASSA TRANSDUCER

Evaluation measurements were made on a Massa M155C transducer at the request of David Taylor Model Basin. The transducer was a cylinder 9 inches long and 2 1/4 inches in diameter, with a magnetostrictive element designed to operate in the frequency range 1 to 50 kc.

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Measurements consisted of transmitting current and voltage response and directivity in the frequency range 1 to 50 kc at hydrostatic pressures to 700 psig. The responses during two pressure cycles showed changes of as much as 8 dB, depending on pressure and frequency. At low hydrostatic pressures, however, the transducer showed good projector characteristics. The transmitting current response had a slope of approximately 10 dB per octave above and below the peak response at 18 kc. At 18 kc and 0 psig the transmitting current responses were 79, 71, and 67 dB re 1 μ bar/A at 1 m with 1000, 2000, and 3200 feet of cable, respectively. (JPS)

Project No. RP-2417 (Unclassified)

ATLANTIC RESEARCH TRANSDUCERS

Four LC32 transducers were calibrated for the Acoustic and Pressure Check Range, Ft. Story, Virginia.

Measurements consisted of free-field voltage sensitivity in the frequency range 2 cps to 100 kc. The sensitivities were between -103 and -104 dB re 1 V/ μ bar in the range 100 cps to 10 kc. (DRH)

Project No. RP-2427 (Unclassified)

CHESAPEAKE HYDROPHONES

Calibration measurements were made on Chesapeake type XT-91C hydrophones serials 1 through 3 at the request of the Bureau of Ships in connection with contract NObsr-87358(FBM).

Measurements consisted of free-field voltage sensitivity in the frequency range 100 cps to 10 kc. The sensitivities were between -88 and -89 dB re 1 V/ μ bar from 100 cps to 1 kc. Resonance occurred at 4.8 kc at a level approximately 23 dB higher than the 1 kc level.

Low-frequency measurements were made at ambient temperature in the range 10 to 1000 cps as a function of hydrostatic pressure. Serials 1 and 3 failed following the 0 psig measurements; serial 2 failed during the 0 psig measurements that followed the release of pressure. The level of serial 2 decreased 1.0 dB at 1000 psig. (EMR)

Project No. RP-2428 (Unclassified)

BTL 5A TRANSDUCER

Measurements were made on a 5A transducer serial 20 for the U. S. Naval Ordnance Laboratory.

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The measurements consisted of directivity and transmitting current and voltage response in the frequency range 10 to 150 kc. The transmitting responses were normal for this type of transducer. (JPS)

Project No. RP-2430 (Unclassified)

MASSA HYDROPHONE

Type M115A hydrophone serial 331 was calibrated at the request of the U. S. Naval Underwater Ordnance Station.

Free-field voltage sensitivity was measured in the frequency range 100 cps through 150 kc. The end-of-cable sensitivity was -99 dB re 1 V/ μ bar in the range 100 cps to 20 kc. (CRB)

Project No. RP-2434 (Unclassified)

HUDSON LABORATORIES HYDROPHONES

Calibration measurements were made on three type 2Z hydrophones at the request of Hudson Laboratories in connection with Office of Naval Research contract N0nr 266(66).

Measurements consisted of free-field voltage sensitivity in the frequency range 100 cps to 20 kc. The sensitivity was approximately -89 dB re 1 V/ μ bar in the ranges 100 to 500 cps for the 2ZPE and 100 cps to 1 kc for the 2ZPF. The sensitivities of both transducers decreased by 2.5 dB at 500 psig, and by 3.0 dB at 1000 psig. The sensitivity of the 2Z12F was -86 dB in the range 100 cps to 1 kc, and did not change with hydrostatic pressures to 1000 psig. (DGW)

Project No. RP-2439 (Unclassified)

HUDSON LABORATORIES HYDROPHONE

Calibration measurements were made on Hudson Laboratories hydrophone serial 1 at the request of the University of Miami, Marine Laboratory, in connection with Office of Naval Research contract N0nr 840(16). The hydrophone was a 6-inch cylinder of 2-inch diameter with a ceramic element of unspecified type and length, and an output transformer within the case.

Measurements consisted of free-field voltage sensitivity in the frequency range 100 cps to 20 kc. The sensitivity was between -104 and -109 dB re 1 V/ μ bar from 100 cps to 1.5 kc. (JLT)

U N C L A S S I F I E D

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Project No. RP-2452 (Unclassified)

OCP-1 SONAR TEST SET

Calibration measurements were made on OCP-1 sonar test set serial 256 with CBSV51112 transducer serial 608, at the request of the Bureau of Ships, for the Argentine Navy.

Measurements consisted of correction factors for the test set, and free-field voltage sensitivity, transmitting current and voltage response, and directivity of the transducer in the frequency range 3 to 40 kc. (JLT)

Project No. RP-2453 (Unclassified)

POMSEE TRANSDUCERS

Measurements were made on POMSEE transducers CBZT51112A serial 1121 and TR-127/WQM-3 serial 261 at the request of the Mare Island Naval Shipyard.

Measurements consisted of free-field voltage sensitivity and transmitting voltage response in the frequency range 3 to 20 kc. Directivity patterns were made at selected frequencies from 3.5 to 14 kc in the horizontal plane. The free-field voltage sensitivity at 10 kc was -124.8 dB re 1 V/ μ bar for CBZT51112A serial 1121, and -108.4 dB for TR-127/WQM-3 serial 261. The transmitting voltage response at 10 kc was 23.4 dB re 1 μ bar/V at 1 yard for CBZT51112A serial 1121, and 19.7 dB for TR-127/WQM-3 serial 261. (KLC)

Project No. RP-2456 (Unclassified)

ATLANTIC RESEARCH TRANSDUCERS

Five LC32 transducers were calibrated at the request of the Navy Hydrographic Office.

Free-field voltage sensitivity was measured in the frequency range 100 cps to 150 kc. Four of these transducers had the normal sensitivity of -105 dB re 1 V/ μ bar from 100 cps to 10 kc. Both the sensitivity and the resistance of the fifth transducer were low. (JLT)

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Project No. RP-2458 (Unclassified)

BM111A HYDROPHONES

Calibration measurements on three BM111A hydrophones were made at the request of the Navy Hydrographic Office.

Measurements consisted of free-field crystal voltage sensitivity in the frequency range 100 cps to 20 kc. The sensitivities were -76.4 ± 0.5 dB re 1 V/ μ bar in the frequency range 100 cps to 5 kc. (RGA)

Project No. RP-2463 (Unclassified)

ATLANTIC RESEARCH TRANSDUCER

LC57 transducer serial 64 was calibrated at the request of the Technical Research Group in connection with Office of Naval Research contract NONr-3208(00).

Free-field voltage sensitivity, transmitting current and voltage response, and directivity were measured in the frequency range 100 cps to 30 kc. At 1 kc the sensitivity was -94 dB re 1 V/ μ bar; the transmitting current response was 60 dB re 1 μ bar/A at 1 m. (JLT)

Project No. RP-2465 (Unclassified)

TYPE AP.A.6021 TRANSDUCER

Free-field voltage sensitivity of transducer AP.A.6021 serial B578, property of the Admiralty Underwater Weapons Establishment, Portland, Dorset, England, was measured to determine whether the sensitivity of the transducer had changed since the previous calibration in November 1961. Sensitivity in the frequency range 100 cps to 2 kc was -99 dB re 1 V/ μ bar, a negligible change from that measured previously and reported under RP-2189 in USRL Quarterly Report 4-61.

Project No. RP-2466 (Unclassified)

ATLANTIC RESEARCH TRANSDUCERS

Two LC10 transducers were calibrated at the request of Martin-Marietta Corporation, Orlando, Florida, in connection with Bureau of Naval Weapons contract NOW 62-0043-1.

Free-field voltage sensitivity was measured in the frequency range 10 to 150 kc. Both transducers had sensitivities of approximately -111 dB re 1 V/ μ bar at 25 kc, the frequency of interest. (JLT)

(Reverse side CONFIDENTIAL) U N C L A S S I F I E D

ACOUSTIC MATERIALS

Project No. RP-2338 (Confidential)

SOUNDAMP TYPE RAL ANECHOIC MATERIAL

This project was a continuation of that reported in USRL Quarterly Report No. 1-62 under the same project number. The earlier measurements were made on a "round hole" type material; these were on a "square hole" type.

For these measurements, as before, a 30 x 30 x $\frac{1}{2}$ -inch-thick sample was bonded to a $\frac{5}{8}$ -inch-thick steel plate. The measurements consisted of per cent reflected and per cent transmitted of normally incident sound intensity for the frequency range 8 to 15 kc, at hydrostatic pressures to 1000 psig.

The per cent of normally incident sound intensity reflected and transmitted at two frequencies and various hydrostatic pressures was:

Pressure (psig)	Reflection (per cent)		Transmission (per cent)	
	10 kc	15 kc	10 kc	15 kc
0	45	60	<1	<1
100	35	45	<1	<1
200	15	25	<1	<1
250	10	15	<1	<1
400	15	15	2	<1
600	45	30	4	1
800	75	45	8	2
1000	85	55	8	4

(JED)

MISCELLANEOUS PROJECTS

Project No. RP-2339 (Unclassified)

ORL EXPERIMENTAL MAGNETOSTRICTIVE FERRITE TRANSDUCER

Evaluation measurements were made at the request of Ordnance Research Laboratory on an experimental magnetostrictive ferrite transducer. The transducer is a piston having 16 Ferroxcube 7A2 double-dumbbell-shaped elements arranged in a 4 x 4 array. There are two sets of windings

designated A and B. The B winding can be operated with its two halves either series aiding or opposing.

The measurements consisted of free-field voltage sensitivity, directivity, and impedance in the frequency range 10 to 30 kc at the water temperature 20°C and hydrostatic pressures to 1000 psig. The free-field voltage sensitivities of both the A and B windings varied throughout the frequency range, and, as the pressure increased from 0 to 1000 psig, the peaks and dips in sensitivity shifted upward by approximately 2.5 kc. At 0 psig the sensitivities ranged from -105 dB re 1 V/ μ bar at 10 kc to -84 dB at 22 kc. At 1000 psig the sensitivities ranged from -105 dB at 10 kc to -87 dB at 20 kc. (JPS)

USRL STANDARD TRANSDUCERS (Unclassified)

Calibration measurements were made on the following 17 USRL standard transducers: H17 hydrophones serials 202, 204, 210, and 217; TP210 hydrophones serials 1, 7, 12, and 14; LC32 transducers serials 148, 154, 179, and 183; F17 transducers serials 1 and 2; DT33A transducers serials 113 and 123; and A28 hydrophone serial 4.

USRL EXPERIMENTAL HYDROPHONE (Unclassified)

Calibration measurements were made on USRL experimental hydrophone H23 serial X1.

USRL STOCK TRANSDUCERS (Unclassified)

Calibration measurements were made on the following 35 transducers for USRL stock: F27 transducer serial 3; J2 transducer serial 4; J9 transducers serials 102, 106, 112, 115, 120, 206, 213, 217, and 227; J11 transducer serial 001; DT33A transducer serial 105; H11 hydrophones serials 6, 20, 132, 133, 138, 141, 142, and 143; BC32C transducer serial 95; M115B hydrophones serials 420, 421, and 485; TP210 hydrophones serials 3 and 11; LC32 transducers serials 147, 234, and 237; BM101A hydrophone serial 130; and H17 hydrophones serials 216, 218, 221, and 228.

BUREAU OF SHIPS NOISE MEASURING EQUIPMENT PROGRAM (Unclassified)

Calibration measurements were made on the following 29 transducers from the stock maintained by the USRL for the Bureau of Ships: DT-99/PQM-1A hydrophones serials 28, 30, 41, 57, 60, 79, 86, 109, 121, 149, 160, 161, 168, 170, 174, 190, 195, 203, 206, 228, 267, 280, 288, 289, 218, 325, 337, 339, and 342.

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BUREAU OF SHIPS POMSEE PROGRAM (Unclassified)

Calibration measurements were made on the following items of equipment from the stock maintained at the USRL for the Bureau of Ships: CPK51065 transducer serial 484; CBSV51112 transducers serials 40 and 608; CBSV51112A transducers serials 135, 137, and 2018; CBZT51112A transducers serials 1121 and 1265; TR-127/WQM-3 transducers serials 27, 38, 218, and 261; and OCP-1 sonar test set serial 256.

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MISCELLANEOUS

JOURNAL ARTICLES BY USRL PERSONNEL

"Reciprocity Parameters Derived from Radiated Power," by W. James Trott.
Journal of the Acoustical Society of America, Vol. 34, No. 7, 989-990,
July 1962.

Abstract: The radiated sound power in the near and far fields of transducers are equated to obtain the plane-wave and cylindrical-wave reciprocity parameters from the spherical-wave reciprocity parameter.

A reprint of this article has been distributed as USRL Research Report No. 65 of 20 September 1962.

USRL TRANSLATIONS

"Absolute Calibration of Microphones in a Diffuse Sound Field," by H. G. Diestel. Translation of "Absolut-Bestimmung des Übertragungsfaktors von Mikrofonen im diffusen Schallfeld," Acustica 10, 277 (1960). USRL Translation No. 21.

EQUIPMENT ISSUED

USRL stock transducers were issued to the following Navy contractors on loan for one year or for the duration of the contract, if contract duration is less than one year:

Daystrom, Inc., Electric Division, Poughkeepsie, New York
H17 hydrophone serial 230

General Dynamics Corporation, Pomona, California
BM101A hydrophone serial 206

Gulton Industries, Inc., Metuchen, New Jersey
M115B hydrophone serial 540

The Magnavox Company, Fort Wayne, Indiana
M115B hydrophones serials 407 and 415
LC32 transducer serial 147
J9 transducer serial 132

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Miscellaneous

Martin-Marietta Corporation, Baltimore, Maryland
J9 transducer serial 140

Martin-Marietta Corporation, Orlando, Florida
BC32C transducer serial 95

Minneapolis-Honeywell Regulator Company, Seattle, Washington
J9 transducer serial 219
M115B hydrophone serial 421

The Raytheon Company, Portsmouth, New Hampshire
H17 hydrophone serial 218
TP210 hydrophone serial 11

Sparton Corporation, Jackson, Michigan
J9 transducers serials 115 and 206
M115B hydrophone serial 485

Titania Electric Corporation, Gananoque, Ontario, Canada
H17 hydrophones serials 216 and 221

USRL stock transducers were issued to the following activities on the usual one-year loan basis:

Key West Test and Evaluation Detachment, Key West, Florida
TR16S transducer serial 17

Mare Island Naval Shipyard, Vallejo, California
H17 hydrophones serials 222 and 228

U. S. Naval Ammunition Depot, Crane, Indiana
J9 transducer serial 230
M115B hydrophone serial 505

U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Maryland
J9 transducers serials 118 and 129

U. S. Navy Electronics Laboratory, San Diego, California
M115B hydrophone serial 425

U. S. Navy Underwater Sound Laboratory, New London, Connecticut
E8 transducer serial 44
M115B hydrophone serial 420
TP210 hydrophone serial 3

Bureau of Ships noise-measuring equipment was issued to the following activities:

Charleston Naval Shipyard, Charleston, South Carolina
DT-99/PQM-1A hydrophone serial 571

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Miscellaneous

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David Taylor Model Basin, Washington, D. C.

DT-55/PQM-1 hydrophones serials 25, 34, 37, 43, and 55

Ingalls Shipbuilding Corporation, Pascagoula, Mississippi

DT-99/PQM-1A hydrophones serials 109, 121, 149, 160, 161, and 168

AN/PQM-1A noise measuring sets (less 400-ft reels) serials 35 and 110

AN/PQM-1A comparator serial 18

Long Beach Naval Shipyard, Long Beach, California

DT-99/PQM-1A hydrophones serials 174 and 190

Mare Island Naval Shipyard, Vallejo, California

DT-99/PQM-1A hydrophones serials 28 and 60

Narragansett Marine Laboratory, University of Rhode Island, Kingston, Rhode Island

DT-99/PQM-1A hydrophone serial 578

Newport News Shipbuilding and Drydock Company, Newport News, Virginia

DT-99/PQM-1A hydrophones serials 576 and 577

Philadelphia Naval Shipyard, Philadelphia, Pennsylvania

DT-99/PQM-1A hydrophone serial 521

Portsmouth Naval Shipyard, Portsmouth, New Hampshire

ME-72/PQM-1A meter serial 68

AM-765/PQM-1A amplifier-power-supply serial 68

DT-99/PQM-1A hydrophones serials 126, 513, and 553

U. S. Naval Engineering Experiment Station, Annapolis, Maryland

ME-72/PQM-1A meter serial 67

AM-765/PQM-1A amplifier-power-supply serial 31

DT-99/PQM-1A hydrophones serials 523, 532, and 539

U. S. Naval Station, Key West, Florida

AN/PQM-1A noise measuring set serial 72

DT-99/PQM-1A hydrophones serials 533, 537, and 538

U. S. Naval Submarine Base, New London, Connecticut

DT-99/PQM-1A hydrophones serials 30, 57, 195, and 203

USS BUSHNELL (AS-15)

AN/PQM-1A noise measuring set serial 9 (less hydrophones and cases)

USS PIPER (SS-409)

DT-99/PQM-1A hydrophone serial 228

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Miscellaneous

Bureau of Ships POMSEE Program equipment was issued to the following activities:

Bureau of Ships, Code 688C, Washington, D. C.
TR-127/WQM-3 hydrophones serials 218 and 225

Mare Island Naval Shipyard, Vallejo, California
TR-127/WQM-3 hydrophones serials 216 and 261
CBSV51112A transducer serial 1121

San Francisco Naval Shipyard, San Francisco, California
TR-127/WQM-3 hydrophone (no serial)

USS KENNETH D. BAILEY (DDR-713)
CBSV51112 transducer serial 40

USS ROBERT K. HUNTINGTON (DD-781)
CBSV51112A transducer serial 137

USS TURNER (DDR-834)
CBSV51112A transducer serial 2018

USS LIDDLE (APD-60)
CPK51065 transducer serial 484

CALIBRATION REPORTS ISSUED

Calibration Reports were issued to the following activities during the period covered by this Report:

Admiralty Underwater Weapons Establishment, Portland, Dorset, England
No. 1921, 29 Aug 1962, Type AP.A.6021 transducer serial B578

Bureau of Naval Weapons, Department of the Navy, Washington, D. C.
No. 1888, 3 Jul 1962, Sonobuoy hydrophones
No. 1889, 10 Jul 1962, Sonobuoy hydrophones
No. 1890, 5 Jul 1962, Sonobuoy hydrophones
No. 1891, 11 Jul 1962, Sonobuoys, noise calibration (Confidential report)
No. 1893, 18 Jul 1962, Sonobuoy hydrophones
No. 1894, 19 Jul 1962, Clevite AX-439 sonobuoy line hydrophones serials 101, 102, and 103 (Confidential report)
No. 1900, 30 Jul 1962, NOPF Mk 44 Mod 0 transducers serials E1 and E2 (Confidential report)
No. 1903, 3 Aug 1962, Bendix-Pacific transducers Mk 46 (DX252) serials 288X and 289X (Confidential report)
No. 1904, 6 Aug 1962, Sonobuoy hydrophones
No. 1905, 8 Aug 1962, Gulton AN/SSQ-45(XN-1) sonobuoy line hydrophones serials 2 and 3 (Confidential report)

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- No. 1906, 9 Aug 1962, Sonobuoy hydrophones
- No. 1908, 10 Aug 1962, Sonobuoy hydrophones
- No. 1910, 15 Aug 1962, Sonobuoy hydrophones
- No. 1912, 16 Aug 1962, Sonobuoy hydrophones
- No. 1914, 20 Aug 1962, LC10 transducer serial 218
- No. 1916, 24 Aug 1962, Sonobuoy hydrophones
- No. 1917, 24 Aug 1962, Sonobuoy hydrophones
- No. 1920, 29 Aug 1962, LC10 transducers serials 218 and 220
- No. 1922, 31 Aug 1962, Sonobuoy hydrophones
- No. 1924, 5 Sep 1962, Clevite AN/SSQ-45(XN-1) sonobuoy line hydrophones serials M101, M102, and M103 (Confidential report)
- No. 1926, 10 Sep 1962, Bendix-Pacific Mk 46 (DX252) transducer serial 291X (Confidential report)
- No. 1933, 28 Sep 1962, Sonobuoy hydrophones

Bureau of Ships, Department of the Navy, Washington, D. C.

- No. 1892, 13 Jul 1962, TR-127/WQM-3 transducers
- No. 1911, 16 Aug 1962, Raytheon AN/BQS-6 transducer elements serials 2 and 4 (Confidential report)
- No. 1913, 17 Aug 1962, Technical Dynamics 550355 transducer serial 10001
- No. 1923, 4 Sep 1962, Sangamo AN/SQS-23 transducer elements serials VDS-2 and VDS-3, and array (Confidential report)
- No. 1929, 21 Sep 1962, Soundamp type RAL (square hole) anechoic coating (Confidential report)
- No. 1930, 26 Sep 1962, Edo AT-200(XN-4) transducer serial X-2 (Confidential report)
- No. 1931, 26 Sep 1962, Chesapeake type XT-91C hydrophones serials 1 through 3
- No. 1932, 27 Sep 1962, OCP-1 sonar test set serial 256, and CBSV51112 transducer serial 608

David Taylor Model Basin, Washington, D. C.

- No. 1886, 2 Jul 1962, Hydro-Tech target-tracking hydrophones serials "Standard", 1, 2, and 3

Hudson Laboratories, Columbia University, Dobbs Ferry, New York

- No. 1901, 30 Jul 1962, Type 2Z hydrophones serials PE, PF, and 12F
- No. 1887, 2 Jul 1962, Massa M155C transducer serial 233
- No. 1898, 23 Jul 1962, Bendix-Pacific transducers DX278 serials 1 and 2 and DX279 serials 1 and 2 (Confidential report)
- No. 1902, 31 Jul 1962, Fiber glass housing

Key West Test and Evaluation Detachment, Key West, Florida

- No. 1897, 20 Jul 1962, Massa TR16S transducer serial 17

Mare Island Naval Shipyard, Vallejo, California

- No. 1915, 23 Aug 1962, CBZT51112A transducer serial 1121 and TR127 transducer serial 261

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Marine Laboratory, University of Miami, Miami, Florida
No. 1909, 13 Aug 1962, Hudson Laboratories hydrophone serial 1

Norfolk Naval Shipyard, Portsmouth, Virginia
No. 1895, 19 Jul 1962, LC32 transducers serials 225, 227,
228, and 231

Ordnance Research Laboratory, The Pennsylvania State University,
University Park, Pennsylvania
No. 1899, 25 Jul 1962, ORL experimental magnetostrictive
ferrite transducer

Technical Research Group, Inc., Syosset, New York
No. 1927, 10 Sep 1962, LC57 transducer serial 64

U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Maryland
No. 1896, 19 Jul 1962, 5A transducer serial 20
No. 1928, 14 Sep 1962, NOL experimental transducer array
(Confidential report)

U. S. Naval Underwater Ordnance Station, Newport, Rhode Island
No. 1907, 9 Aug 1962, M115A hydrophone serial 331

U. S. Navy Hydrographic Office, Washington, D. C.
No. 1919, 28 Aug 1962, LC32 transducers serials 210, 213, 215,
217, and 219
No. 1925, 5 Sep 1962, BM111A hydrophones serials 101, 104, and 107

U. S. Navy Mine Defense Laboratory, Panama City, Florida
No. 1918, 28 Aug 1962, Mine hunting sonar system and Nimrod hydro-
phone (Confidential report)

Calibration data were issued on the following 43 transducers for USRL stock: J2 transducer serial 4; J9 transducers serials 102, 105, 106, 112, 115, 118, 120, 129, 132, 140, 206, 217, 219, 227, and 230; J11 transducer serial 001; F27 transducer serial 3; BC32C transducer serial 95; LC32 transducers serials 147, 234, and 237; M115B hydrophones serials 407, 415, 420, 421, 425, 484, 505, and 540; H17 hydrophones serials 216, 218, 221, 222, 228, and 230; TP210 hydrophones serials 3 and 11; BM101A hydrophones serials 130 and 206; H11 hydrophone serial 12; and E8 transducers serials 23 and 31.

Calibration data were issued on USRL experimental hydrophone H23 serial X1.

Under the program of maintenance of noise-measuring equipment managed by this laboratory for the Bureau of Ships, calibration data were issued on the following 19 hydrophones: DT-99/PQM-1A hydrophones serials 28, 30, 57, 60, 79, 86, 109, 121, 149, 160, 161, 168, 170, 174, 190, 195, 203, 206, and 228.

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Calibration data were issued on the following transducers under the Bureau of Ships POMSEE Program: CPK51065 transducer serial 484; CBSV51112 transducer serial 40; CBSV51112A transducers serials 137 and 2018; and TR-127/WQM-3 transducer serial 218.

TRAVEL

J. F. Prandoni, Head, Engineering Services Department, attended the course titled "Analysis and Design of Modern Pressure Vessels," given at the University of California, Los Angeles, California, during the period 15-28 July.

T. A. Henriquez, Physicist, Transducer Division, attended the Seminar on Underwater Acoustics held at The Pennsylvania State University, University Park, Pennsylvania, from 23 to 27 July.

W. J. Trott, Head, Research and Development Department, attended the meeting of the Navy Underwater Sound Advisory Group in Washington, D. C., on 13 August.

J. F. Prandoni, Head, Engineering Services Department, and R. J. Kieser, Head, Engineering Branch, Transducer Division, attended the meeting of the Inter-Service Committee on Technical Facilities held at Redstone Arsenal, Huntsville, Alabama, on 14 and 15 August. Mr. Kieser gave a talk on "Construction Techniques on a Fiber Glass Sphere for Underwater Pressure Measurements."

O. M. Owsley, Director, and E. A. Barnes, Physicist, visited the Office of Naval Research and the Naval Research Laboratory in Washington, D. C., on 6 and 7 September.

ATTENDANCE AT TECHNICAL MEETINGS

R. J. Bobber, Head, Research Division, attended the Fourth International Congress on Acoustics held in Copenhagen, Denmark, from 21 to 27 August where he presented a paper titled "Transducer Calibration from Near-Field Data." At the conclusion of the Congress, he visited Saclant ASW Research Center in La Spezia, Italy, and the Admiralty Underwater Weapons Establishment at Portland, England.

OFFICIAL VISITORS

Official visitors to the USRL during the period covered by this Quarterly Report were:

Clark A. Sheridan, Clifton M. Wyant, J. A. Merrill, and William E. Beasley, Bendix-Pacific Division, The Bendix Corporation, North Hollywood, California

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Jim H. Riley, Bureau of Ships, Washington, D. C.
Chester Plachta, Bureau of Yards and Docks, Washington, D. C.
Donald J. Karbo, Clevite Ordnance Division, Clevite Corporation,
Cleveland, Ohio
Joseph G. Carter, David Taylor Model Basin, Washington, D. C.
S. Trebisacci, General Dynamics Corporation, Electric Boat Division,
Groton, Connecticut
Wilson J. Remick and Roger J. LaVine, General Electric Company,
Utica, New York
Glenn N. Howatt, Gulton Industries, Inc., Metuchen, New Jersey
E. J. Dressel, J. Ray McDermott and Company, Inc., New Orleans,
Louisiana
James A. Hill, North American Aviation Corporation, Columbus, Ohio
R. I. Tompkins, Office of Naval Research (Code 360), Bureau of Naval
Weapons Patent Division, Washington, D. C.
F. Robert Hill and Carl J. Zink, Raytheon Company, Newport,
Rhode Island
William H. Benedict, Robert L. Clemens, and Jack A. Siebert,
Sangamo Electric Company, Springfield, Illinois
Jack W. Wise and A. W. Martin, U. S. Naval Ordnance Laboratory,
Silver Spring, Maryland
J. C. Duke, Jr., and William G. Harris, Jr., U. S. Navy Mine Defense
Laboratory, Panama City, Florida
John Libuha, U. S. Navy Underwater Sound Laboratory, New London,
Connecticut

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